Report on the Health of Colorado's Forests 2004

Special Issue: Ponderosa Pine Forests

April 6, 2005

The 2004 Report on the Health of Colorado's Forests explores the unique issues and challenges of sustaining and managing ponderosa pine forests in the state. Subsequent reports will provide a similar investigation of the other major forest types that characterize Colorado's unique landscapes.

As members of the Colorado Forestry Advisory Board, we feel it is important for all Coloradans to better understand both the natural processes and human decisions that led to our current forest conditions – and what options we have for improving those conditions in at-risk areas.

Many of us regularly interact with ponderosa pine forests, at our homes, on our way to work, while recreating in the forest, or through benefits such as wildlife habitat, watershed protection and diverse wood products. A significant body of scientific research suggests that, in some areas, the condition of our ponderosa pine forests is ecologically unsustainable. Catastrophic wildfires in recent years illustrate this risk. If we wish to maintain these forests and the benefits they provide, we must act to restore them to their natural resiliency.

Throughout Colorado, diverse groups of stakeholders have joined forces to improve the condition of ponderosa pine forests in and around their communities. In some cases, their objective is to protect their own lives and property from fire. But in other examples, the community is interested in protecting the larger landscape or watershed that enhances and sustains their lives.

Both of these objectives must be approached with a solid understanding of ponderosa pine ecology and the likely impacts of various management strategies.

Community Wildfire Protection Plans, as described in the Healthy Forests Restoration Act, provide an excellent tool for helping communities consider both public safety and ecological restoration challenges.

We encourage Coloradoans to participate in these and related efforts so that our ponderosa pine and other forested landscapes will continue to sustain a healthy range of conditions and benefits for several generations to come. It is our hope that this Report will motivate and inform your involvement.

Sincerely,

Nancy M. Fishering
Chairperson, Colorado Forestry Advisory Board

Colorado Forestry Advisory Board Members:

2004 Report on the Health of Colorado's Forests

Executive Summary

The *2004 Report on the Health of Colorado's Forests* begins with an overview of significant incidents and trends in forest insect and disease activity across the state. The remainder of the Report provides an in-depth examination of the ecology, condition and management of Colorado's ponderosa pine forests. Unlike previous editions, which highlighted a range of forest health concerns, this and future Reports will focus on the research related to a particular forest type. These detailed, science-based investigations should effectively deepen Coloradans' understanding of the forested landscapes that surround them and the challenges that lie ahead in ensuring long-term forest sustainability.

Cooler temperatures and increased moisture during 2004 brought much needed relief to drought-stricken vegetation across Colorado. Insect and disease activity tied to extreme drought stress began to subside in many areas, including the southwest and southcentral parts of the state that experienced epidemic piñon ips beetle activity and corresponding piñon pine mortality during the previous year. Despite this movement toward recovery, the extent and intensity of insect and disease activity continues to be a concern in many forests. Aerial surveys recorded approximately 1.2 million trees killed by mountain pine beetle outbreaks in 2004. This is nearly one hundred times the mortality reported in 1996.

Many of Colorado's forests evolved with natural cycles of insects, disease and other forms of disturbance, such as fire. In ponderosa pine forests, this disturbance promoted diversity and resilience across the landscape. Historical ponderosa pine stands in Colorado ranged from relatively open woodlands in the southwest to moderately and even extremely dense forests along varying elevations of the Front Range. Beginning with the gold rush in 1858, Euro-American settlement and land management practices disrupted the natural disturbance cycles that shaped these forests. The near exclusion of fire after 1910 proved particularly detrimental to some ponderosa pine landscapes.

Current ponderosa pine forests in Colorado are generally denser and more homogeneous in terms of age and size than prior to Euro-American settlement. These conditions can put individual trees in intense competition for light, water and other critical resources, resulting in stressed forest stands that are less able to fight off insect and disease attacks. In addition, increased tree and understory density places some ponderosa pine forests at heightened risk for large-scale and/or high intensity wildfire. Fires of the magnitude seen in Colorado during 2002 can have numerous adverse impacts on ponderosa pine forests and surrounding watersheds, including landscape-scale tree mortality, severe soil damage, loss of seed sources, establishment of invasive species and damage to critical wildlife habitat.

The potential for widespread and destructive wildfires is of particular concern to communities in the high-risk wildland-urban interface. Ponderosa pine forests characterize approximately 75 percent of the

Merrill R. Kaufmann

The restoration of a more open canopy and greater age and size diversity has made this forest more resilient to disturbance.

interface zone in Colorado, a statistic that encompasses 1,274 communities. Land management treatments that thin the forest through selective harvest and reintroduce fire through prescribed burning can reduce the risk of fire to individual homes and communities. In some ponderosa pine landscapes, these treatments can also restore the forest to more historical – and therefore more sustainable – ecological conditions.

Determining a viable course of action in any particular forested landscape requires an analysis of both historic and current forest conditions. Land managers must also establish a desired future condition for the landscape and consider the social, political and economic realities that may affect their ability to achieve that condition. The most effective solutions are found when land managers, policymakers, homeowners, community leaders, scientists and others join forces to achieve a mutually desirable end result.

Many Colorado communities have already undertaken a collaborative approach to managing ponderosa pine forests. Notable examples include the Ponderosa Pine Forest Partnership in southwest Colorado, the Greater Laramie Foothills Project northwest of Fort Collins, and the Harris Park Community Wildfire Protection Plan southwest of Denver. Community Wildfire Protection Plans, as described in the *Healthy Forest Restoration Act (P.L. 108-148)*, provide a valuable new tool to assist diverse local interests in identifying and addressing their mutual concerns for public safety, community sustainability and natural resources.

Peter Barth

Ponderosa pine forests offer valuable opportunities to combine education, research and management.

Ponderosa pine forests represent one of six major forest types in Colorado. Other significant forest types that will be addressed in future reports include aspen, piñon -juniper, mixed conifer, lodgepole pine and spruce-fir. The information in the *2004 Report on the Health of Colorado's Forests* incorporates a substantial body of both analytical and applied research and reflects a tremendous public concern for the sustainability of these forests across the state. This and subsequent reports should serve as valuable material for those working to find solutions to Colorado's forest management challenges.

2004 Insect and Disease Activity Update

Many of Colorado's forests began taking steps toward recovery during 2004, after struggling through several years of severe drought. Cooler temperatures, earlier monsoon weather patterns and increased moisture provided relief for thirsty trees in urban, rural and mountain environments. The dramatic spread of piñon ips beetles in southwest and southcentral Colorado slowed significantly, as did damage from other species of ips beetles at lower elevations. Mortality in ornamental blue spruce along the Front Range dropped off in July as afternoon rains increased.

Dave Leatherman

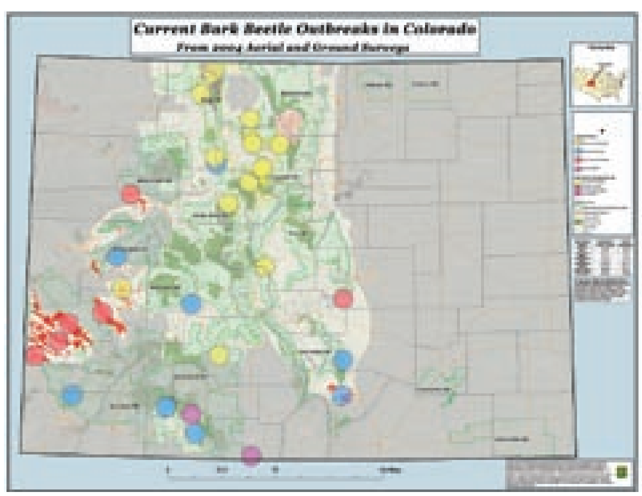
Beetle-caused piñon pine mortality is substantial throughout southwest Colorado. This view looks south towards Mesa Verde National Park.

Despite these signs of improvement, the trends in insect and disease activity initiated by previous years of stress continue to play out across the state's forested landscapes. Epidemics of mountain pine beetle continue to flourish and spread in hard hit areas. Trees strained by earlier drought conditions continue to die, and insect populations continue to reproduce in record numbers and remain active for longer periods of time.

Native aspen stands throughout Colorado show impacts from drought as evidenced by myriad diseases and insects, including cankers, decay and rot diseases, wood borers, and bark and ambrosia beetles in dead and declining trees. The appearance of three new minor hardwood bark beetles underscores the depth of the drought's reach in that it spared very few species from vulnerability. The sighting of these beetles could also signal the northward shift of traditionally southern species as a result of climate change. The progression of significant insect activity into higher elevation forests is also a likely signal of lingering drought and warming climates. It will take several years of normal to above normal moisture for affected forests to regain their resiliency to attack.

The banded elm bark beetle discovered for the first time in Colorado in 2003 was confirmed to carry the causal fungus that leads to Dutch elm disease. Although sightings of the beetle declined substantially in 2004, the appearance of a new carrier for Dutch elm disease is of concern, particularly to Front Range communities that lost up to 60 percent of their American elms during the last three or more decades.

The majority of Colorado's insect and disease activity continues to stem from native species. Regular cycles of insect and disease outbreaks are an important component of a functioning forest ecosystem. The current condition of many Colorado forests has caused these natural cycles to operate at scales and severities that match



USDA Forest Service, Rocky Mountain Region

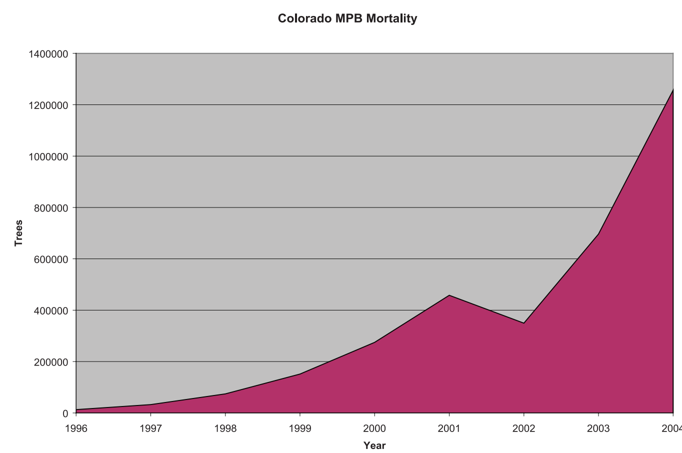
Large-scale bark beetle outbreaks continue to expand in many Colorado forests.

or exceed previous records. The most effective way to reduce unwanted damage in areas of high public value is to reduce stress or alleviate competition prior to attack. Once epidemic-level infestation has begun, management options in affected areas are limited.

Mountain Pine Beetle (*Dendroctonus ponderosae*)

While many areas around the state are reporting static or declining mountain pine beetle activity, epidemic conditions continue to exist and expand in "hotspots" where beetle-caused mortality has been extremely high since the early 1990s. Mountain pine beetle is the most significant damaging insect of Colorado's pine forests and particularly favors older, dense stands of ponderosa, lodgepole and limber pines. Aerial surveys in 2004 recorded 1,256,320 trees killed by beetle activity. That compares to 696,400 reported killed in 2003, 275,000 in 2000 and 13,000 in 1996.

In Grand County, lodgepole pine mortality continues to be high in major outbreak areas located around Lake Granby and in the Williams Fork and Troublesome Creek watersheds. Mountain pine beetle impacts are also increasingly evident in higher elevation sites in this region, with pockets of mortality observed above 10,000 feet. This expansion is likely due to warmer summer temperatures that allow epidemics to occur at higher elevations than is considered normal. Mountain pine beetle activity in this area is currently the most damaging insect and disease situation affecting Colorado's state and private lands.



Randy Moench

Mountain pine beetle mortality in Colorado has risen exponentially since the beginning of the current outbreak in the early 1990s.

High visibility areas in Summit County also continue to experience expanding mountain pine beetle activity, as do lodgepole pine stands on the Colorado State Forest in eastern North Park and the Yampa Ranger District of the Routt National Forest. On the Front Range, there is notable mountain pine beetle activity in ponderosa pine, both north and south of the Upper Poudre Canyon near Fort Collins.

Colorado State Forest Service

An aerial view reveals extensive mountain pine beetle mortality in forests near Boulder.

In the southern portion of the state there are two major outbreaks of mountain pine beetle that have been occurring for the past several years. An outbreak that started in Chaffee County's Arkansas River valley has spread roughly along the course of the river and into the Wet Mountains, the eastern slope of the Sangre de Cristo mountains and forested areas to the south of Cañon City. Another major outbreak is in the vicinity of the Vail Valley along the I-70 corridor, where beetle attacks have had a visible impact on lodgepole pine forests around the ski area and in urban-interface zones around homes and other development. While activity in these areas has slowed, the beetles appear to be moving north of the Interstate, with areas of increasing mortality in the Redstone Canyon / Piney Lake area. Significant mortality can be expected in the future.

Other areas with fairly intense pockets of mountain pine beetle activity include portions of the San Juan, Rio Grande, Gunnison and Uncompahgre National Forests, where drought conditions could encourage beetle activity to rise to epidemic levels. Increased beetle activity in bristlecone and limber pine at higher elevations may be ecologically significant when combined with the effects of drought, climate change and newly discovered threats such as white pine blister rust.

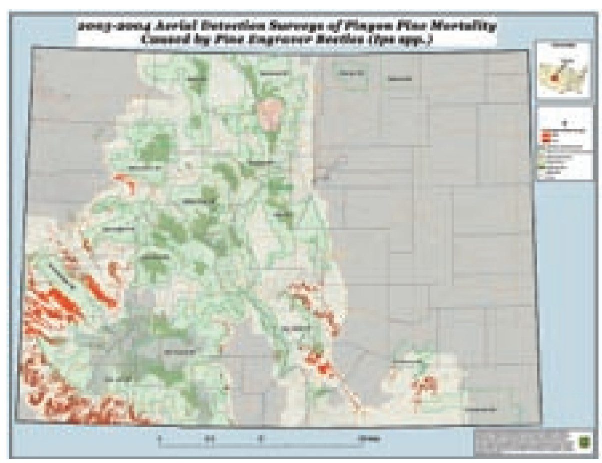
Piñon Ips Beetle (*Ips confusus*)

Perhaps the most dramatic recent example of tree mortality in the central Rocky Mountains has been the extensive loss of piñon pine due to an epidemic of piñon ips beetle activity. This outbreak is occurring on a tremendous scale with several species of piñon being affected throughout the Southwestern United States.

In Colorado, mortality has been particularly severe in the southern portion of the state with more than a million acres affected to some extent and many thousands of acres experiencing the loss of up to 90 percent of mature piñon trees. Recent drought conditions are the root cause of the outbreak, but fairly high tree densities and the overall even-aged status of piñon stands are contributing factors. The heaviest losses to date have occurred around Durango, Cortez and Dolores in the Four Corners region. Significant piñon mortality has more recently moved into the Grand Junction area. Activity in these areas probably peaked in 2004.

The future of the outbreak depends greatly upon weather conditions. The rains of 2004 slowed the epidemic on the southern Front Range. But, even with favorable weather conditions, the slow growth of piñon stands means that many woodlands and forests will not regain a mature piñon component for some time. Preventive spraying in spring and fall appears to be working to protect individual trees against ips attack. In areas where twig beetles are attacking all new growth, however, a third spraying may be needed in late spring.

The overall situation in piñon-juniper forests is further complicated by increased activity from cedar bark beetles (*Phloeosinus spp.*), which have killed pockets of junipers statewide. They were particularly noted in southwestern Colorado and on the Front Range and eastern plains. They are generally not aggressive and are assumed to have been aided by the drought.



USDA Forest Service, Rocky Mountain Region

Drought and piñon ips beetle activity combined to result in heavy piñon pine mortality in several areas of Colorado.

Spruce Beetle (*Dendroctonus rufipennis*)

Spruce beetles are on the increase in many parts of Colorado, partially due to mild weather conditions that allow the beetle completing its life cycle in one year instead of the normal two. As a result, some field observers have noted more rapid population growth than has been seen historically. Aerial surveys for 2004 report 154,654 trees killed over 62,171 acres.

Other factors found to increase the risk of spruce beetle attack include: well-drained creek bottom growing sites; stands with larger diameter trees or high densities; and stands with an overstory made up of at least 65 percent spruce.

In southern Colorado, the majority of spruce beetle activity is occurring in scattered pockets of less than 100 acres, but on several sites large numbers of mature spruce have been killed over extensive areas. About 30 known sites of significant spruce beetle activity currently exist on the Routt, White River, Grand Mesa, Gunnison, Uncompahgre, San Juan and Rio Grande National Forests.

Dave Leatherman

Mortality from spruce beetle activity is evident in this forest north of Steamboat Springs.

Spruce beetle activity that resulted from the 1997 Routt Divide Blowdown continues to expand and intensify. The Mt. Zirkel Complex fire occurred in the same area in 2002 and further stressed the region's already at-risk forests. Hundreds of thousands of spruce have been killed in Routt and Jackson Counties in the years since these events. The main zone of impact continues to range from north of Rabbit Ears Pass to the Wyoming border. Beetles appear to be increasing in the Elkhead Mountains west of the main blowdown areas.

Spruce beetle outbreaks are also cause for concern on private land throughout the mountains, especially where large-diameter trees exist at high densities. The age of many Colorado spruce forests suggests they are ready to regenerate through large-scale disturbance. Further outbreaks are likely inevitable. Moisture and climate conditions will be key factors in how soon these outbreaks occur.

Subalpine Fir Decline

Subalpine fir decline continues to occur at significant levels in Colorado and is one of the greatest causes of forest mortality in the state. Approximately 675,974 trees were reported killed in 2004 on nearly 275,000 acres. The condition is caused by a combination of western balsam bark beetle activity (*Dryocoetes confusus*) and various root disease pathogens, particularly *Armillaria ostoyae*. Losses of subalpine fir have been particularly significant throughout southern Colorado and on the Uncompahgre Plateau. On several ski areas, the loss is a concern for area managers. The widespread nature of the mortality, combined with the fact that tree death is caused by a combination of insect and fungal activity, means there are few options for managerial response. Maintaining stands with a wide range of age classes is probably the most prudent course of action to reduce long-term impacts.

Dave Leatherman

Subalpine fir decline is prevalent in many of Colorado's high-elevation forests, including this location on the east side of Monarch Pass.

Western Spruce Budworm (*Choristoneura occidentalis*)

The southern portion of the Uncompahgre Plateau has seen significant levels of western spruce budworm defoliation in Engelmann spruce, as have areas of the San Juan and Rio Grande National Forests below Wolf Creek Pass. This activity suggests that budworm activity is on the increase in high elevation forests. Heavy defoliation also occurred in Larimer County near Cherokee Park. Acreages of Douglas-fir with light and moderate defoliation increased along the Front Range of El Paso and Douglas Counties. Isolated pockets of activity were detected in north central Colorado on several ownerships and near La Veta Pass. Activity was reduced in the Wet and Sangre de Cristo Mountains, which have experienced chronic budworm defoliation in previous years.

USDA Forest Service, Intermountain Region Archives

Western spruce budworm activity has increased in Engelmann spruce on the Uncompahgre Plateau.

Dwarf Mistletoes (*Arceuthobium spp.*)


Dave Leatherman

Lodgepole pine dwarf mistletoe is just one of several mistletoes that impact Colorado's conifers.

Dwarf mistletoes chronically affect several conifer species in Colorado. With recent mild winter conditions and periods of drought, dwarf mistletoes are contributing to mortality in many areas of the Rocky Mountain region, including Boulder, Clear Creek, Gilpin, Douglas, Park and El Paso Counties.

Dwarf mistletoe is the most important health factor for lodgepole pine and is estimated to infest about 50 percent of Colorado's lodgepole pine stands. Historically, the extent and spread of this parasitic plant has been limited by large, stand-replacing fires. With the advent of intense fire suppression, the range and severity of mistletoe infection in lodgepole pine has increased.

Ponderosa pine dwarf mistletoe is widespread throughout the host type in Colorado and infests approximately 20 percent of the ponderosa pine forests along the Front Range. Dwarf mistletoe is also a continuing problem in the ponderosa pine stands of the Black Forest near Colorado Springs.

Typical impacts of mistletoe include formation of "witches brooms" in crowns and branches; reduction in tree growth and seed production; and increased susceptibility to insect attack, root disease and storm damage.

Gambel Oak Dieback

Drought conditions combined with late frosts caused a massive dieback of Gambel oak throughout Colorado. One result of this condition was a build-up of the Gambel Oak Flatheaded Borer (*Agrilus quercicola*). Along the southern Front Range and in the Durango – Cortez area, this led to attacks on and losses of ornamental oaks. Denver and Colorado Springs were also particularly hard hit. Subsequent rainfall lessened stress on the host plants and reduced the chances that activity and damage will continue at serious levels.

Douglas-fir Beetle (*Dendroctonus pseudotsugae*)

Douglas-fir beetle continues to kill mature trees in areas scattered throughout its Colorado range. Aerial surveys in 2004 recorded 62,274 trees killed on 41,452 acres. In a few cases, drought conditions seem to have encouraged increased Douglas-fir beetle activity in areas of chronic defoliation by western spruce budworm (*Choristoneura occidentalis*). Another common association is for Douglas-fir beetle to infest trees damaged but not killed by fire; this is occurring near South Fork on the site of the 2002 Million Fire.

Dave Leatherman

Douglas-fir beetle activity creates unique galleries in the wood of affected trees.

Douglas-fir Pole Beetle (*Psuedohylesinus nebulosus*)

While this insect is rarely considered a major pest species, it has killed many hundreds of mature Douglas-fir in the eastern portion of the San Juan National Forests. As the common name suggests, this insect most frequently attacks smaller diameter Douglas-fir, but trees up to 12 inches in diameter are being killed near Pagosa Springs. This beetle was also detected in high numbers in the Wet Mountains near Westcliffe, north of Durango and in the southern San Juan Mountains. Drought conditions likely contributed to the susceptibility of large numbers of host trees. Douglas-fir engraver beetles (*Scolytus reflexus* and others) caused additional mortality in small-diameter Douglas-fir throughout the host range.

Hardwood Bark Beetles

Three hardwood bark beetle species rarely seen or never before recorded in Colorado were detected in 2004, probably due to both recent drought conditions and possible impacts from climate change. These species are: *Pityophthorus juglandis*, a southwestern species found for the first time in Colorado in the Denver / Boulder area and also in Colorado Springs in ornamental black walnuts; *Typophloeus striatulus*, found in an alpine species of oak near Molas Divide; and *Pityophthorus virilis*, found on skunkbush sumac at the Garden of the Gods near Colorado Springs.

White Pine Blister Rust (*Cronartium ribicola*)

This disease of white pines, which originated in Asia, was separately introduced from Europe to both the east (late 1800's) and west (1921) coasts of North America and is now moving into Colorado. It is spreading both southward from Wyoming and northward from New Mexico. It is well-established in limber pines in Larimer County and has recently been discovered in the Sangre de Cristo mountains east of the San Luis Valley. The latter infections of bristlecone pines near Mosca Pass are speculated to have arrived via wind dispersal of spores from known infections in New Mexico. This disease may have serious consequences for both limber and bristlecone pine in Colorado. While neither tree is economically important, they are both of unquestioned ecological significance. Primary management options are to minimize human movement of infected ornamental plants (both pines and the alternate hosts, which are currants (*Ribes spp.*) and hope that resistant individuals persist naturally in native white pine stands exposed to the disease.

Ponderosa Pine Forests in Colorado

Introduction

When considered against the backdrop of geologic time, ponderosa pine forests are a relatively recent component of Colorado's landscape. They arrived from the south a mere 5,000 years ago, following the close of the last ice age. By the mid-nineteenth century, when gold was discovered and settlers descended on Colorado in great numbers, ponderosa pine forests were well established in the southwest part of the state and along the foothills and mountains of the Front Range.

Early residents took advantage of the readily-accessible, low elevation ponderosa pine forests to graze livestock and harvest timber for homes, businesses and the mining and railroad industries. Due to the significant impacts of human activity, few existing ponderosa pine landscapes exhibit the spatial or structural features of the forests that existed prior to Euro-American settlement.

Although ponderosa pine forests have been subjected to substantial change over the past century, research on historic landscapes has provided useful insights for evaluating and improving the condition of current forests. Much of the resulting body of knowledge revolves around the role of fire in ponderosa pine ecosystems and the degree to which disruptions in natural fire cycles have put these forests – and the people that live in and around them – at risk.

Like many of Colorado's forest types, ponderosa pine landscapes are disturbance driven, meaning they evolved with natural cycles of wildfire, insect and disease infestations, flooding, avalanches and windstorms. The primary change agent for ponderosa pine is fire.

Land management policies, including the exclusion of fire from forests for much of the last century, had a significant impact on ponderosa pine throughout its range. In New Mexico and Arizona, scientists have found that ponderosa pine stands are much more dense today than prior to Euro-American settlement. These forests have also experienced substantial invasion by Douglas-fir and are generally more prone to damaging, large-scale wildfires.

In Colorado, where ponderosa pine forests occur on a greater diversity of sites and in varied vegetative combinations, the departure from historic conditions seems most pronounced in the southwest part of the state and at elevations between 5,500 and 8,000 feet along the Front Range.

Beginning in the late 1980s, several large-scale wildfires burned in Colorado's ponderosa pine forests, threatening lives, homes, communities and watersheds with their intensity and resulting devastation. Approximately 75 percent of the state's high-risk wildland-urban interface is characterized by ponderosa pine landscapes. This fact has been underscored by events such as the Black Tiger Fire (1989), Buffalo Creek Fire (1996), Hi Meadow Fire (2000), Bobcat Gulch Fire (2000), and Hayman Fire (2002) on the Front Range, the Coal Seam Fire (2002) in Glenwood

Kent Grant

Ponderosa pine trees provide a wide range of benefits to Colorado's communities and visitors.

Springs and the Missionary Ridge Fire (2002) outside of Durango. The need to address this combined community and resource protection challenge has prompted increased attention to ponderosa pine forests and their management.

Ponderosa pine forests occur on a wide variety of landscapes and diverse site conditions in Colorado.

Land managers, policymakers, homeowners and community leaders have joined researchers in asking questions such as:

- Are these fires natural?
- Did they occur at this size and severity prior to human settlement?
- What role does the forest's condition play?
- Can the forest be restored to a more sustainable condition?
- How can land managers reduce risks to communities from fire?
- Can ecological restoration and risk reduction be accomplished simultaneously?

While the answers are not unanimous, a strong consensus is building around the need for reduction of forest fuels to protect communities and on the benefits of ecological restoration in selected ponderosa pine forests. Questions persist about the need for restoration activities at higher elevations in Colorado, but the importance of risk reduction in those areas remains.

In some Colorado communities, people representing diverse interests have come together to explore solutions to ponderosa pine management on the ground. Projects such as the Ponderosa Pine Partnership in southwest Colorado and the Front Range Fuels Treatment Partnership involve multiple ownerships, interests and disciplines; apply science to management practices; and monitor results to inform future actions. Many of these coalitions are also exploring related management challenges such as fuel treatment costs, disposal or utilization of resulting woody materials, and the need for broad public engagement and support.

Community Wildfire Protection Plans, as described in the recently passed Healthy Forests Restoration Act (P.L. 108-148), provide a much-needed vehicle for bringing together diverse local interests to discuss their mutual concerns for public safety, community sustainability and natural resources. Participation in this planning process will allow communities to assess fuels treatment needs in a broader, solution-oriented context that also considers ecosystem restoration issues, fire response capability and individual responsibility for home-site protection.

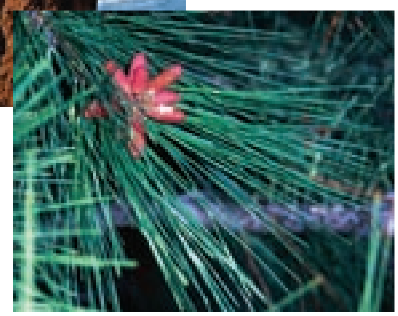
Ponderosa pine forests are literally in the backyards of many Colorado communities. The condition of these forests impacts water quality and quantity, the availability of healthy wildlife habitat, opportunities for scenic and recreational experiences, and the ability of both residents and visitors to safely and sustainably enjoy their desired quality of life.

Ponderosa pine forests represent Colorado's best opportunity to combine research and public values in a way that both improves community protection and increases ecological resilience.

Ponderosa Pine Overview

The broad spreading branches, long, bundled needles and generally conical form of the ponderosa pine (*Pinus ponderosa scopulorum*) are familiar to many Coloradoans who live, work and recreate in their midst. Its tall trunks and relatively high branches provide an ideal space for shaded picnics, and its rough, furrowed bark is said to give off the scent of vanilla when warmed by the sun. Many birds and small animals such as mice, chipmunks and squirrels prize the seeds from its moderate-sized cones.

Paige Lewis



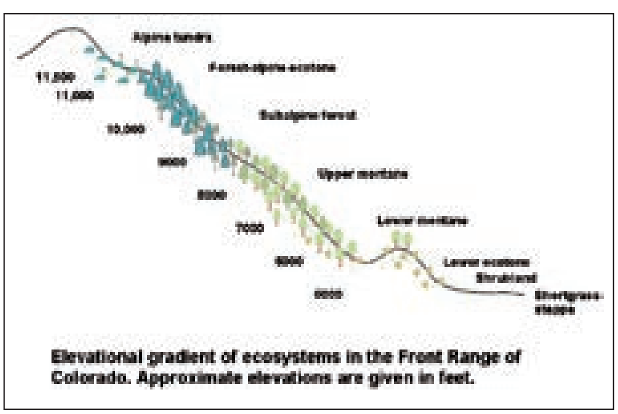
Keith Wood

Thick bark and long protective needles enable ponderosa pine trees to survive low-intensity surface fires.

Scottish botanical explorer David Douglas first identified the ponderosa pine in 1826 while traveling in the Pacific Northwest. He subsequently named it in recognition of its heavy, or ponderous, wood. Studies of packrat middens indicate that ponderosa pine existed in northern New Mexico 11,000 -12,000 years ago and reached the area near Colorado Springs about 5,000 years ago (Julio Betancourt pers. comm.). Now widely distributed throughout western North America, ponderosa pine forests occupy approximately three million acres in Colorado and grow on sites with a wide range of topographic and environmental conditions.

Elevation and moisture availability are key factors in determining where ponderosa pine occurs, which plant communities accompany it, and how fire and other ecological processes function within the forest. Although ponderosa pine is most common in Colorado's *montane* life zone, between 6,000 – 9,000 feet, it begins to appear on the landscape at around 5,000 feet, where prairies and shrublands transition into open ponderosa forests. At these lower elevations, ponderosa pine may occur in pure stands or mixed with piñon pine, juniper, and oak brush. Extensive patches of grassland or shrubs are also common.

As elevations increase, ponderosa pine may be found in combination with Douglas-fir and aspen, particularly on wetter, or *mesic*, sites and north-facing slopes. In the upper montane zone, usually at or above 7,500 feet in the Front Range, ponderosa pine may be found in pure stands on dry, or *xeric*, sites. But at these elevations, it more commonly makes a transition into mixed conifer stands that may include lodgepole and limber pine as well as aspen and Douglas-fir.



Merrill Kaufmann

Elevation and moisture help determine the type of forest that occurs on a particular site.

Climate, soils, topography and disturbance patterns combine to determine the unique structure and composition of a forest. These environmental factors also shape the *historic range of variability*, or diversity of conditions, that could exist in a particular forest ecosystem over time. An understanding of the dynamic processes that created a forest landscape can aid managers in determining what steps to take in restoring that landscape to more historic and/or resilient conditions.

Ecology and Agents of Change

Like many of Colorado's forests, ponderosa pine landscapes are characterized as *disturbance driven*, meaning they evolved with natural cycles of wildfire, insect and disease infestations, flooding and windstorms. Although insects and diseases such as mountain pine beetle and dwarf mistletoe have played a key role in shaping the state's ponderosa pine forests, the primary disturbance agent – prior to Euro-American settlement – was wildfire. Since 1860, human activities such as timber harvest, grazing, fire suppression and urban development have been significant catalysts for change.

The influence of Native Americans on historical fire regimes is difficult to reconstruct and therefore unclear. Evidence suggests that they used fire to alter landscapes, but it is likely that the impact of these fires was localized in space and time.

Wildfire

Ponderosa pine is particularly well adapted to survive low-intensity fire. It has thick bark that insulates the cambium from heat, long sparse needles that shield buds, and branches that self-prune at the base of the crown, thereby reducing the chance that fire will climb into the canopy (Oliver and Ryker 1990). There is ample evidence that in historic landscapes trees exposed to fire often survived, even when damaged. Surviving trees frequently recorded both the year and season of the fire in their growth rings, providing a valuable source of information for forest researchers (Stokes and Smiley 1968, Brown et al. 1999).

Merrill Kaufmann

Frequent cycles of surface fire served to rejuvenate many pre-settlement ponderosa pine forests.

These adaptations caused ponderosa pine to be favored over more fire sensitive species such as Douglas-fir, which has thinner bark when young, more dense and compact foliage and branches that extend close to the ground. Low-severity surface fires could move through historical ponderosa pine forests in a cleansing rather than damaging way. Pine needles, grasses, shrubs and competing conifer seedlings would be consumed, while established and mature ponderosa pines often survived and thrived with increased access to light, water and nutrients.

Periodically, small groups of older trees were killed by cycles of bark beetles, resulting in openings in the canopy conducive to the establishment of new pine seedlings. These young trees would gradually be thinned by competition, insects, disease and fire, eventually replacing the older trees that previously occupied the site (Brown and Aplet 2000). Occasional episodes of crown fire also resulted in scattered meadows and persistent openings on the landscape.

Fire behavior is shaped by interactions between vegetative fuels, weather and topography. Patterns of fire severity and frequency over time and space are known as *fire regimes*. Regional differences in historic fire regimes resulted in a variety of forest stands and landscapes in Colorado and throughout the West.

Two main types of fire regimes exist in ponderosa pine. In *surface-fire regimes*, relatively frequent low to moderate intensity fires burned throughout forest stands with little mortality in the forest canopy. In *mixed-severity fire regimes*, fires burned somewhat less frequently and with variable intensity, consuming whole patches of forest in some areas while leaving other areas with little or no canopy mortality at all.


USDA Forest Service

Historical ponderosa pine forests in the Southwest were often described as open and park-like.

Surface-fire regimes were particularly common in ponderosa forests of the southwestern United States where predictable summer rainfall, longer growing seasons and the influences of the El Nino climatic cycle caused fires to occur about every three to seven years, with most fires having no stand-replacing component (Covington and Moore 1994, Woolsey 1911). Resulting landscapes were often described as open and park-like, characterized by scattered mature trees. Crown fires were exceedingly rare.

Researchers have found that Colorado's ponderosa pine forests historically exhibited a broad range of fire patterns, depending on their geographic location, elevation and related environmental conditions. In lower-elevation forests of southwest Colorado, fires in ponderosa pine were frequent and largely burned as surface fires, much like those in Arizona and New Mexico (Grissino-Mayer et al. 2004). Scientists working in the San Juan Mountains found historical fire intervals of 6-10 years in low elevation ponderosa pine forests and 18-28 years in high elevation mixed conifer forests.


Merrill Kaufmann

Mixed severity fires burn intensely in some areas while leaving other patches of forest less affected or even untouched.

Fire regimes along Colorado's Front Range appear to differ from north to south and along an elevational gradient. While regular climatic cycles play a critical role in regulating fire in the southwest (Swetnam and Betancourt 1990), summer monsoon moisture is less reliable on the Front Range and has been shown to decrease in influence in the northern parts of the state (Woodhouse and Brown 2001). In addition, the Front Range's cold, less productive soils caused surface fuels to build up and dry out more slowly, making them less likely to support regular cycles of surface fire. Historic fire intervals in these forests could be 50 years or more.

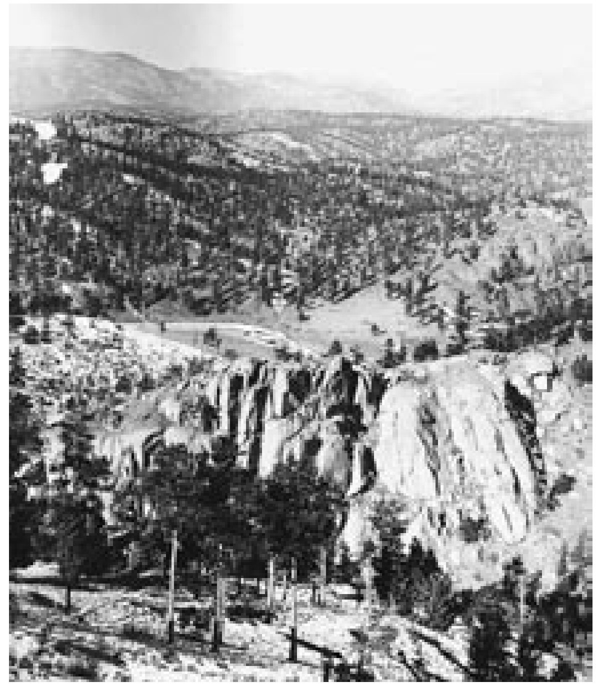
Variable fire regimes and site conditions produced a range of ponderosa pine landscapes in Colorado. Over the past decade, extensive research has been conducted into historical fire cycles in both the lower and upper montane zones of the Front Range.[1] While these studies differ with regard to their impli-

[1] The use of the terms *upper montane* and *lower montane* stems from a study of forest types in Rocky Mountain National Park and east toward the plains (Peet 1981). In this study, the elevation at which the transition between life zones occurs appears to be around 8,000 feet. At the higher elevations, ponderosa pine exists in either pure stands or with a mix of other conifer species, usually at densities referred to as 'forest,' and normally on drier sites. At lower elevations, types having a significant ponderosa pine component are often classified as 'woodland,' meaning they are more open in nature. These lower elevation forests generally, and occur across a much wider moisture range, with forests on moister lower elevation sites having higher densities, more dominance by Douglas-fir, and less dominance by ponderosa pine.

cations for forest management, the resulting body of research provides valuable insights into the pre-settlement conditions of Colorado's ponderosa pine and the extent to which current forests are outside the historic range of conditions that could have existed prior to Euro-American settlement.

Lower Montane Ponderosa Pine Forests in the Front Range

Since 1994, scientists from the Rocky Mountain Research Station of the USDA Forest Service have conducted an extensive research program on ponderosa pine / Douglas-fir forests in the lower montane life zone of the South Platte watershed southwest of Denver (Kaufmann et al. 2000 a and b, 2001, 2003 and Huckaby et al. 2001). This 7,500-acre landscape, which now surrounds Denver Water's Cheesman Lake, was unique prior to the 2002 Hayman Fire because it was not logged and had been fenced to exclude livestock grazing since 1905. Although most of the landscape was severely burned in the Hayman Fire, sampling and research prior to the event yielded rich information about the area's fire history.



Denver Water

Historical forests around Cheesman Lake were much more open and diverse than many current ponderosa pine landscapes.

Fires in the lower montane forests at Cheesman Lake, and elsewhere in the South Platte watershed, historically were less frequent than reported in southwestern Colorado or near the grassland / woodland transition zone of the Front Range. Ignitions of small, low-intensity fires undoubtedly occurred, but they generally left behind little or no evidence in the form of fire scars. For these forests, longer periods of time between fires resulted in the accumulation of vegetative fuels and fuel ladders, which would allow surface fires to climb into forest crowns.

Merrill Kaufmann

Prior to the 2002 Hayman Fire, the modern-day forests around Cheesman Lake resembled many lower montane forests along the Front Range.

A number of large fires occurred around the area now occupied by Cheesman Lake, burning a significant part of the landscape roughly every 50 years. It took an average of 75 years for an area equivalent to the entire landscape to burn. These fires were mixed in severity, including both surface fire and patchy, lethal overstory fire.

Most of the historic landscape exhibited sparse canopy cover, with the amount of land area covered by tree crowns ranging from 0 to 30 percent. Actual tree densities varied from 0 to 20-40 trees per acre depending on past fires and seedling establishment patterns. Ponderosa pine was dominant on all but north-facing slopes, where Douglas-fir dominated steeper areas.

Ponderosa pine or ponderosa pine/Douglas-fir forests similar to those found in Douglas and Jefferson Counties have also been identified in lower elevation portions of the Big Thompson and Poudre River watersheds in Larimer County and in some portions of Boulder County. Fire histories observed in several northern Front Range sites suggest similar fire behavior patterns (Brown and Shepperd 2001), though landscape-scale analyses similar to those made possible by the historically intact Cheesman landscape are not available.

Merrill Kaufmann

Upper montane forests exhibit a more complex mixture of species, tree densities and distribution patterns.

Upper Montane Ponderosa Pine Forests in the Front Range

Forest ecologists from the University of Colorado at Boulder and other institutions have conducted studies of historic fire regimes in upper montane ponderosa pine and mixed conifer forests around the area of Boulder and Larimer Counties (Veblen and Donnegan 2004, Ehle and Baker 2003). These studies reveal a historic variety of forest landscapes ranging from pure ponderosa pine stands to complex mixtures of species, tree densities and distributions on the ground (Veblen et al. 2001, Sherriff 2004). While ponderosa pine and Douglas-fir are common components of the upper montane zone, research suggests that the ecology of this zone may be significantly different from that of lower elevations.

A growing body of evidence in northeast Colorado suggests that mixed conifer forests in the upper montane zone, which typically include some lodgepole pine, were often characterized historically by a mixed severity fire regime. Fires of this pattern would burn along the forest floor in some places while consuming patches or even entire stands of trees in others, leaving a complex pattern of species dominance, age structure and other forest conditions across the landscape (Huckaby and Kaufmann unpublished data, Sherriff, 2004). It is widely suggested that these fires would decrease in frequency but could increase in severity with rising elevations. Patterns of fire frequency at higher elevations are strongly driven by regional drought.

Euro-American Settlement

Euro-American settlement brought dramatic change to Colorado's ponderosa pine forests, resulting in a greater departure from historical conditions that in any other forest type in the state. Although Native American activity cannot be discounted, it does not appear to have impacted natural fire cycles to the extent of post-1850 activity (Cassells 1983).

Good access, even in winter, made ponderosa pine forests a prime resource for early settlers. Timber harvests supplied lumber for homes and businesses and supported mining, railroad construction and other industrial development. Initial logging entries generally removed the larger, predominantly old growth component of historical ponderosa pine landscapes. Subsequent harvests removed many of the remaining trees. This activity opened the forest canopy and disturbed the soil, resulting in conditions favorable for the germination and establishment of dense crops of new seedlings (Kaufmann et al. 2000a).

Grazing became excessive in many settled areas, and overgrazing was common during drought years early in the 20th century. The Manitou Experimental Forest northwest of Colorado Springs was established in the late 1930s to help address impacts of overgrazing. In many forests, the disruption of regular fire cycles may have begun with heavy livestock grazing because it reduced grasses and other fine fuels that once carried surface fires across the landscape. Large numbers of new tree seedlings thrived in an environment with reduced competition from grasses and forbs.

As Euro-American populations expanded across the West, the risk of large-scale wildfires became increasingly unacceptable. During the early twentieth century, federal land managers instituted a policy of aggressive fire suppression in an effort to protect budding communities and critical natural resources. The regular fire cycles that had once promoted diversity and resilience in many forest ecosystems were essentially eliminated by this policy. Subsequent research revealed that fire scars that had formed on trees fairly regularly prior to Euro-American settlement abruptly ceased, indicating that a major natural disturbance process had been disrupted (Brown et al. 1999, Brown and Shepperd 2001, Grissino-Meyer et al. 2004, Veblen et al. 2000).

The combination of grazing, logging and fire exclusion during post-1850 settlement contributed to the establishment and survival of millions of young ponderosa pine seedlings that would grow to maturity in the absence of fire and without its renewing, regenerative influence.

The second half of the twentieth century brought a different kind of human impact on forests in the form of increasing numbers of people building homes and communities in the midst of previously wildland settings. In Colorado, this wildland-urban interface primarily exists in the ponderosa pine forests that cover the lower-elevation foothills and mountains within commuting distance of larger towns and cities. An estimated 600,000 to 750,000 Coloradans currently live in areas characterized by fire-prone ponderosa pine forests.

USDA Forest Service

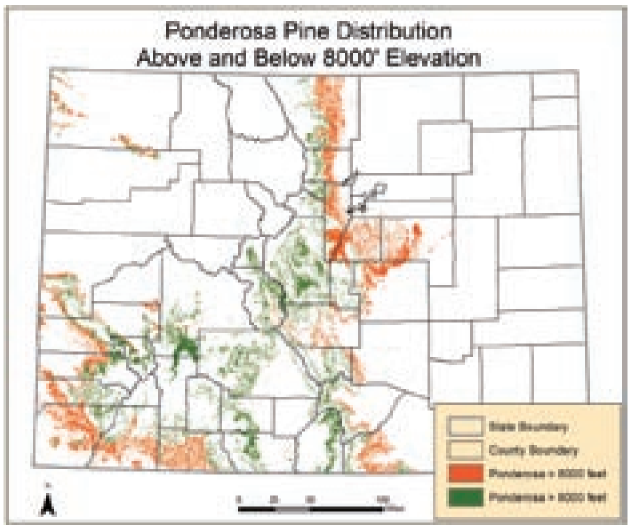
Cattle were often used to haul logs during the nineteenth and early twentieth century.

Consequences of Change

The disruption of natural disturbance cycles has transformed millions of acres of forest and woodland in Colorado and throughout much of the West (USDA Forest Service 2000a). Thousands of acres of dense, homogeneous forest now characterize landscapes that once sustained a complex mosaic of forest density, size and age. There is general agreement that many of these landscapes are increasingly vulnerable to unnaturally large and severe wildfires. Such events pose a tremendous risk to the lives and property of surrounding communities and threaten the long-term sustainability of traditional forest values such as wildlife habitat, watershed integrity, and cultural and aesthetic considerations. The question that remains is what, if anything, should be done to reduce this risk and restore more resilient forest conditions?

Current Conditions

Colorado's ponderosa pine forests, particularly at lower elevations, are arguably more adversely affected by altered disturbance cycles than are other forest types in the state. Dense forest regeneration in the wake of grazing, logging and fire suppression resulted in vast stands of trees having approximately the same age and size. The lack of subsequent disturbance allowed most of these trees to survive, creating continuous canopies of pine trees that are now under stress from competition for resources. One consequence of this condition is that when disturbances such as insect outbreaks and fire do occur, the existing forest does not have either the diversity or resilience needed to survive the event. Many existing lower elevation forests are unsustainable in their present condition.



Colorado State Forest Service

There are approximately 3 million acres of ponderosa pine in Colorado.

Throughout the lower-elevation ponderosa pine / Douglas-fir zone of Colorado, current ponderosa pine forests differ from historical forests at both the larger landscape scale and smaller stand level. Where there were once open park-like landscapes in the southwest and more fragmented, complex landscapes along the Front Range, both supporting large numbers of old trees, there are now more dense, younger and less diverse ponderosa pine forests extending across large areas of the entire state.

In many locations, stands that were historically pure or nearly pure ponderosa pine now include competing species such as Douglas-fir and piñon pine. Shrubs such as mountain mahogany and Gambel oak have also grown up in the understories, creating ladder fuels that can carry fire from the ground to the crowns of large trees.

Increased competition for resources has also made these forests more vulnerable to attack from insects and disease. This has been particularly true during the last decade of the twentieth century and early part of the twenty-first, when warmer temperatures and several years of extreme drought left ponderosa pine – and less drought-tolerant trees – struggling just to survive. While ponderosa pine evolved with cycles of disturbance from native insects and disease, current conditions have made those cycles longer and more widespread in some locations.

Dan Wand

Trees in this dense ponderosa pine forest east of Bayfield face intense competition for light, water and nutrients.

Fire Size and Severity

A dramatic consequence of the current condition of ponderosa pine and other forests across Colorado has been the advent of larger and more severe fires than previously recorded. The 1989 Black Tiger Fire near Boulder forewarned of an impending shift in fire behavior, particularly for ponderosa pine sites along the Front Range. The fire quickly burned 2,100 acres and 44 homes and other structures. While the Black Tiger Fire was viewed as somewhat of an aberration, subsequent fires set a pattern of large, rapidly moving, stand-replacing fires, many of which burned with devastating severity.

In 1996, the Buffalo Creek Fire burned nearly 12,000 acres of ponderosa pine forest in the South Platte watershed southwest of Denver. The majority of the fire burned so severely that entire stands of forest were consumed and soils became resistant to water absorption, prompting subsequent flooding and severe erosion. In 2000, the Bobcat Gulch fire near Fort Collins and the Hi Meadow fire south of Denver burned over 10,000 acres each and destroyed more than 60 homes.

Merrill Kaufmann

Post-settlement land use patterns resulted in dense, homogenous stands of ponderosa pine at increased risk from wildfire.

The combination of drought, stressed forest conditions and extreme weather patterns made 2002 the state's most dramatic fire year yet, with the majority of fire events burning in moderately to extremely dense ponderosa pine forests. The Schoonover, Snaking and Hayman wildfires burned on the same landscape previously impacted by the Buffalo Creek and Hi Meadow fires.

The Missionary Ridge Fire outside of Durango, the Burn Canyon Fire near Telluride and the Spring Complex west of Trinidad indicated that the problem was not limited to the Front Range.

The Hayman Fire grew to be Colorado's largest fire in recorded history, burning 138,000 acres and 133 homes and incurring suppression costs of $39 million. Prior to 2002, the state's largest fire was the 14,000 acre Black Ridge Fire in La Plata County. Reports of conditions on the Hayman fire were similar to those from other fire events that year: dense, extremely dry ponderosa pine forests with thick understory vegetation, the lowest fuel moisture levels in thirty years, and extreme, wind-driven fire behavior.

Merrill Kaufmann

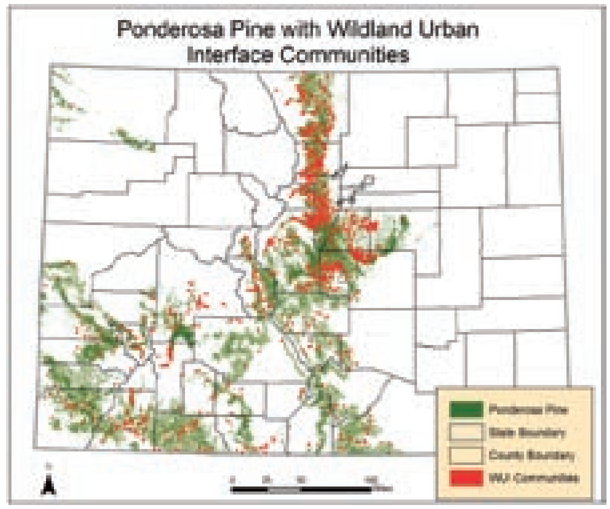
The 2002 Schoonover Fire was just one of several large-scale wildfires to burn in Colorado's ponderosa pine forests in recent years.

In areas of Colorado where surface fires occurred historically, these kind of high-severity crown fires are highly atypical. Even in areas with mixed-severity regimes, the size of the patches created by recent fires appears to be considerably larger than occurred historically.

In both situations, the occurrence of crown fires with large areas of complete tree mortality is inconsistent with ecological sustainability (Kaufmann 2000b, 2001). Large crown fires reset the ponderosa pine landscape to an unforested condition. Unlike lodgepole pine, which regenerates naturally after an intense fire, a ponderosa pine stand may only regenerate from the fire's perimeter where mature trees provide a seed source. Reestablishment of older forests takes at least several centuries, as the old-growth condition does not occur until individual trees are about 200 years old (Kaufmann 1996). Re-formation of soils and recovery of genetic diversity takes even longer.

Human Lives and Communities

The increase in widespread and destructive wildfires in Colorado is cause for particular alarm in the wildland-urban interface, where increasing numbers of homes, businesses and other components of community infrastructure are intermingled with high-risk forest fuels. Approximately 75 percent of Colorado's communities-at-risk from wildfire, a total of 1,274 communities, are characterized by or lie within one mile of ponderosa pine forests. Nearly 45 percent of Colorado's ponderosa pine forests are in private ownership.



Colorado State Forest Service

Approximately 75 percent of Colorado's communities at risk from wildfire are characterized by ponderosa pine forests.

The fires of 2002 forced more than 81,000 people to flee their homes, sometimes more than once, and resulted in the destruction of 384 primary residences and 624 other structures. Much of the season's $152 million in suppression costs was driven by the need to use all available resources to protect life and property in the wildland-urban interface. In addition to the loss of homes, communities reported numerous other personal and economic impacts including loss of business and tourism; damage to power, telephone and water utilities; and health impacts from reduced air quality.

Firefighters consider the interface zone one of the most dangerous and complicated firefighting situations they face (Keller 2003). Fire suppression in the wildland-urban interface demands training, procedures, and equipment for both structural and wildland fire. Interface incidents also present additional challenges, including: community evacuation; hazardous material response; narrow access to structures; uncertain water supply; communication and coordination between multiple jurisdictions; extraordinary values-at-risk; and heightened public and media attention.

Merrill Kaufmann

The proliferation of people and structure in the forest dramatically increases the values threatened by wildfire.

Human presence in the forest also increases the risk of human-caused fires. While abandoned campfires and carelessly discarded cigarettes are well-known fire hazards, home or land owner activities also result in wildland fires. Furthermore, homes and structures represent a tremendous fuel source. Flammable building materials, the presence of hazardous household chemicals and fuel tanks, and dense vegetation in the surrounding landscape can increase the intensity of an oncoming fire or the escape of a domestic fire. Ironically, development in the interface often limits land managers' ability to implement hazard reduction tools such as forest thinning and prescribed fire.

Watershed Integrity

Tom Wardle

Healthy forests contribute to water quality and productive aquatic habitat.

Healthy watersheds are not as vulnerable to ecological events outside the historical range of variability. Evidence of ash layers in deep sediment exposed after the Buffalo Creek fire (Elliott and Parker, 2001) suggests significant fire and erosion events over a period of two thousand years, though the size and severity of earlier fires may be difficult to gauge.

Watersheds become ecologically unhealthy when major ecosystem components and processes change and the system becomes vulnerable to events that are outside the historical norm. Such is the case for many watersheds currently forested with ponderosa pine and Douglas-fir in Colorado. This has been particularly true in the Upper South Platte watershed and other areas of the Front Range in the lower montane zone (Wohl 2001).

Fire ecologists use the term *burn severity* to refer to the effects of fire on soil conditions and hydrologic function. In general, the denser the pre-fire vegetation and the longer the fire burns on a particular site, the more severe the impacts on soil and its ability to absorb and process water. High severity wildfires remove virtually all living forest vegetation above the ground, including trees, shrubs and grasses, and consume fallen needles, decomposed roots and other elements of ground cover or *duff* that protect forest soils.

The loss of critical surface vegetation leaves forested slopes extremely vulnerable to large-scale soil erosion and flooding during subsequent storm events. These risks threaten the communities and natural resources downstream, but can also adversely affect watershed integrity over the long-term. The presence of highly erosive soils in several parts of the state, and weather patterns that frequently bring heavy rains after fire season, can result in difficult and expensive challenges long-after the fires are out. In 2002, at least 26 municipal water storage facilities were closed due to wildfire impacts.

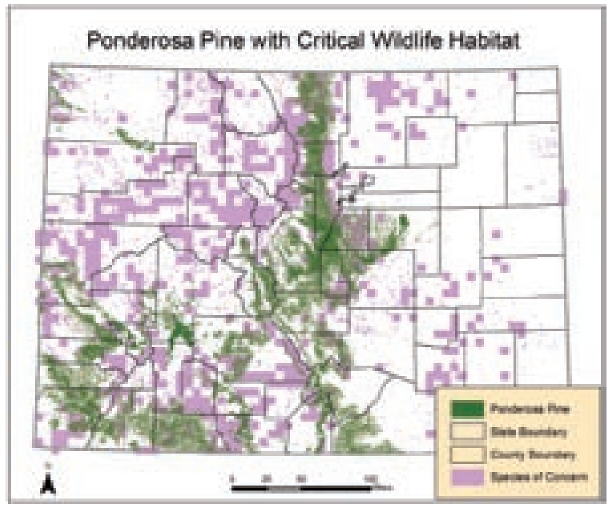
Public and private entities invest millions of dollars to implement emergency measures that protect people, communities and critical resources from post-fire events such as flooding, erosion, mudslides, and related degradation of water supplies and storage facilities. In the wake of the 2002 wildfire season, federal agencies invested more than $26 million in emergency rehabilitation, while at least $16 million was invested to shore-up non-federal lands.

Even in the absence of large, severe fires, watershed conditions may be negatively affected by increased forest density. Lower montane forests in northeast Colorado provide relatively small amounts of annual runoff and are not considered a potential source for increasing the water available for human use. Nonetheless, in such dry ecosystems, even limited runoff can provide significant support to riparian vegetation in portions of watersheds supplied by intermittent or seasonal water flow. With high forest densities, such intermittent flow is reduced or even eliminated, and it is likely that the extent of riparian communities in many watersheds has been reduced.

Habitat and Biodiversity

The natural biodiversity of Colorado's ponderosa pine forests developed over a period of many centuries. Mule deer and Rocky Mountain elk live throughout these forests along with several smaller mammals including chipmunks and voles. Many bird species are also seen, including

Steller's jay, brown creeper, white and red-breasted nuthatches, juncos, red-shafted flicker, and the colorful western tanager. The tassel-eared Abert's squirrel uses the tree for nesting, food and shelter and is a distinctive inhabitant of ponderosa pine forests on the central and southern Colorado Plateau.



Colorado State Forest Service

Ponderosa pine forests provide valuable habitat for several wildlife species in Colorado.

Changes to ponderosa pine forests during the last few decades have been particularly rapid and extensive, threatening the sustainability of diverse plant and wildlife communities. Wide-ranging wildlife species, such as deer and elk, that are accustomed to open forests and woodlands at lower elevations have found less suitable habitat in recent years.

Threatened or endangered species have been put at risk by habitat reduction caused by increases in both forest density and fire severity. In the Upper South Platte watershed of the Front Range, the habitat required by the Pawnee montane skipper, a threatened butterfly, is open forest woodland with grassy meadows that include blue grama grass and prairie gayfeather, the butterfly's preferred forage. This habitat has been reduced dramatically in recent decades. The viability of the Pawnee montane skipper was even further threatened by recent drought and by the destruction of 40 percent of its known habitat in the 2002 Hayman and Schoonover fires. Subsequent skipper populations dipped to about 5 percent of their known historical average (Leslie Ellwood, pers. comm.).

While this is an extreme example, it documents the potential for ecological harm when the ponderosa pine system has reached conditions that are considered unsustainable. Equally serious is the threat of invasion by non-native species. This is a particular concern in burned areas because exotic plants can impede or prevent the re-establishment of native vegetation and associated habitats.

Michael H. Francis ©

The Abert's squirrel is a distinctive inhabitant of ponderosa pine forests on the central and southern Colorado Plateau.

Weed seeds are carried into burned areas by wind, clothing, vehicles, soil erosion, flooding and sometimes through aerial seeding or failure to use weed-free erosion-control materials. Species of primary concern in Colorado include orange hawkweed, spotted knapweed, yellow toadflax, leafy spurge and cheatgrass. Studies of understory plant diversity before and after the Hayman fire indicated the presence of 16 non-native plant species on the post-fire landscape (Fornwalt et al. 2003). The ecological and economic consequences of species invasions vary, but analyses leave little doubt that under certain circumstances the costs can be enormous if left unchecked. Early detection and treatment, followed by subsequent monitoring, are essential to maintaining the ecological integrity of areas affected by fire.

Management Options

The current condition of many ponderosa pine forests in Colorado threatens the long-term sustainability of diverse natural resource values and poses a more immediate hazard to human lives and property in the wildland-urban interface. Land managers, policymakers, homeowners and community leaders have joined researchers in asking what should be done to address this challenge.

The answers are complex and varied. Determining a viable course of action in any particular forested landscape requires an analysis of: the historic conditions that shaped that landscape, the current conditions that exist on the ground, the desired future condition for the landscape, and the social, political and economic realities that may affect the extent to which that desired condition can be achieved.

Land owners and managers can address the current condition of Colorado's ponderosa pine forests by reducing vegetative fuels to protect homes and communities, by improving the resiliency of the forest through broader ecological restoration or by combining the two approaches.

There is broad agreement that strategic fuels reduction is needed to reduce wildfire risks to human lives and structures. There is also agreement that in many lower elevation ponderosa pine forests, risk reduction and ecological restoration can often be achieved simultaneously.

In higher elevation forests, where historic fire patterns were more complex, it is unclear whether fuel reduction treatments to reduce risks to human communities would also contribute to ecological restoration and/or a return to pre-settlement conditions. Also, in many areas, the existence of human development itself may preclude certain management options and complicate large-scale implementation.

Ecological / Landscape Restoration

Landscape restoration requires that forest conditions be improved at a large enough scale to affect the behavior of ecological processes such as fire. To attempt this kind of restoration means looking beyond a group of homes to be protected or even an individual forest stand. It involves working at a landscape or watershed scale and assessing the historic range of variability that existed there. Management considerations should include soil conditions, hydrology, and species and habitat diversity, as well as cycles of fire and other disturbances that produced the resulting composition of the forest.

In the ponderosa pine forests of southwest Colorado and portions of the Front Range, current forest density is likely a result of prior logging and grazing and more recent fire suppression. Thus, the thinning of smaller trees and the reintroduction of low-intensity surface fire would contribute to the restoration of historic conditions and lead to increased forest resiliency. To be truly effective, these treatments would need to be implemented at large enough scales to reduce the likelihood of large, stand-replacing fires and to restore the diversity in age, size, density and species distribution created by natural fire in historical landscapes (Romme et al. 2003). After initial

Merrill Kaufmann

Forest managers reduced tree densities and created openings on this landscape near Trumbull in hopes of restoring historical conditions and resilience.

treatments, regular prescribed burning would likely be needed to maintain the critical role of fire in the ecosystem.

At higher elevations and on more moist sites along the Front Range, fire exclusion probably has had less influence on current ponderosa pine forest densities. Research suggests that in some of these areas, natural fires in the early 19th century prompted regeneration of the dense, even-aged stands seen today (Veblen 2002). Restoration of historical conditions in these forests would require a component of high-intensity large-scale fire, an activity that would be unsafe in many locations due to the existence of human development.

Fuels Treatment / Hazard Reduction

The *National Fire Plan*, the *Ten Year Comprehensive Strategy for Reducing Wildland Fire Risks to Communities and the Environment*, the *Healthy Forests Restoration Act*, and many other federal, state and local policies emphasize fuels reduction as a means of lessening wildfire risks to people and communities. In contrast to ecological restoration, fuel reduction projects tend to focus specifically on mitigating risks to people, homes, communities or critical infrastructure and resources.

Hazardous fuel treatments remove live or dead vegetation in order to reduce the potential for large or intense wildland fire. They also aim to improve opportunities for firefighters to operate safely in suppressing fire and to increase the ability of forests to survive a wildfire. Values slated for protection often include municipal watersheds, critical species and habitats, cultural resources, and scenic and recreational opportunities.

Dave Root

When tree crowns are close together or touching, fire can spread quickly through the forest canopy.

Forest fuels are divided into three basic categories (O'Brian 2004):

- Crown Fuels – Live and dead material in the canopies of trees
- Surface Fuels – Grass, shrubs, litter and woody debris in contact with the ground surface
- Ground Fuels – Organic soil, duff, and buried wood.

The fire hazard for a particular area is determined by assessing the potential magnitude of fire behavior and resulting ecological effects based on the type, density, condition and continuity of fuels on the ground. Fire behavior is also influenced by fuel moisture and wind patterns.

Thinning, or mechanical treatment, is a silvicultural practice that reduces forest density by removing some portion of trees and shrubs from a site. This, in turn, reduces the amount and continuity of live or dead fuels. With less fuel to burn, potential fire intensity and spread rates are lessened. Additional benefits include improved forest vigor and resiliency.

Thinning from below is the most common treatment used to reduce wildfire risk in ponderosa pine forests. This technique involves removing only small to mid-sized trees while leaving larger trees that are more resistant to fire. Thinning from below reduces both ladder and canopy fuels and lessens the chance that surface fires will climb into forest crowns and result in unnaturally intense or large wildfires.

Wood mastication or chipping involves grinding or chipping trees, converting them from standing live biomass to dead material on the ground. Like thinning, this technique removes fuels from the forest canopy. Many areas currently are being treated with mulching or chipping machines because there is limited economic demand for small diameter trees or wood chips. The long-term ecological consequences of this approach are unclear, however, especially where large quantities of wood are deposited on the forest floor.

Dan Wand

Thinning was used in this forest near Durango to increase spacing and crown separation between individual trees.

Prescribed fire is another technique commonly used in ponderosa pine forests, particularly in the Southwest, to remove surface fuels. Prescribed fires are planned, intentionally ignited and carefully managed to achieve a particular resource objective. They are often intended to mimic the natural surface fires that once moved through these forests, but are also useful for consuming woody debris created through thinning operations. Sometimes naturally ignited fires are managed in a similar way if they meet a set of predetermined conditions and objectives.

Thinning is often required prior to prescribed burning because current forest densities can dramatically increase or intensify fire behavior. Prescribed burning is also a less precise tool for restoring particular structural conditions to a forest. Burning, however, releases a pulse of nutrients into forest soils that does not occur with logging. Prescribed burning is also a very effective means of maintaining restored conditions once they are achieved. A combined treatment of thinning and prescribed fire is often the most effective.

Land managers face additional challenges in implementing fuel reduction, including: the economic costs of the treatment; the removal of subsequent woody debris; the diversity of public opinions regarding forest management; the challenge of managing across multiple land ownerships; and the need for long-term maintenance of treatments. Overcoming these challenges often involves reaching out to community leaders, interest groups, and the general public, to ensure that fuel reduction projects are in the highest priority areas and supported locally.

While the effectiveness of fuel treatments in altering fire behavior is still being assessed, studies following the 2002 fire season in Colorado indicate that treatments can be effective if implemented at the appropriate scale. Strategically placed fuel breaks in Mesa Verde National Park, for example, protected critical buildings and residences from the flames of the Long Mesa Fire. On the Hayman Fire, the Polhemus prescribed burn site, the early season Schoonover Fire and a thinning project at

Peter Barth

Prescribed fires are used to consume surface and ladder fuels and to restore low-intensity fire to ponderosa pine ecosystems.


Jennifer Chase

Woody materials that result from forest management activities are often disposed of through mechanical chipping or grinding and then scattered on the site.

the Manitou Experimental Forest all appeared to successfully alter the path and lower the intensity of the oncoming blaze (Graham 2003).

Several smaller or older treatments were not up to Hayman's challenge, however, and failed to deter or change the fire's path. These examples suggest that fuels treatment projects achieve maximum effectiveness when they are implemented on a landscape scale, across ownership boundaries, and are maintained over the long-term so that forest regrowth does not eliminate treatment benefits.

Recent studies also show that homeowners can significantly reduce their risk from wildfire by taking action to reduce the flammability of their home and surrounding landscape. Even low-level surface fires can destroy a home if it is composed of highly-flammable materials vulnerable to flying embers or if it is situated on a landscape at-risk to fire.

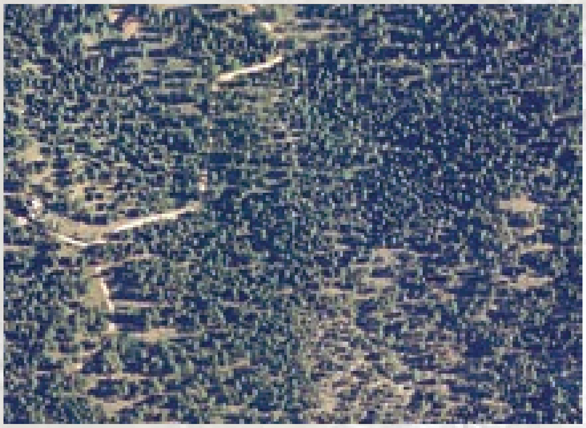
Homeowners in the wildland-urban interface can go a long way toward protecting themselves and their property by following guidelines outlined by FireWise (www.firewise.org) and similar education programs. Common recommendations include cleaning debris from gutters; moving firewood, propane tanks and other combustible materials away from the home; pruning trees and removing ladder fuels to prevent surface fire from climbing into tree crowns; using fire-resistant roofing, siding and other construction materials; and ensuring safe access to the home and property for firefighters.

A General Forest Restoration Prescription for Front Range Ponderosa Pine

The Colorado State Forest Service (CSFS) works with individuals; local, state and federal land management agencies; community coalitions and a variety of other interests along the Front Range to improve the condition of ponderosa pine and other forests. Many of these projects serve as demonstration areas and pilot efforts to test the effectiveness of various land management treatments and to explore related issues such as partnership building, cost-effectiveness, impacts on wildlife habitat and watersheds, and fuels treatment technologies.

The treatment strategies listed below were developed by CSFS Forester Chuck Dennis based on research conducted in Front Range forests and information gleaned through several years of on-the-ground project implementation and monitoring. The objective of this treatment prescription is to restore forest stand conditions to the historical range of variability that existed prior to 1870 along the Front Range.

Because of differences in landscape histories, site conditions, and political and social realities, no single set of management recommendations is appropriate across the entire range of ponderosa pine in Colorado. But this prescription provides a good example of the kinds of goals and strategies land managers consider in developing a fuels treatment or landscape restoration plan.



Colorado State Forest Service

Before – A dense ponderosa pine forest west of Denver prior to thinning.

Colorado State Forest Service

After – The same forest after thinning to protect adjacent communities.

Detailed Treatment Strategies

1. **Save the Oldest Trees** – When thinning, retain most trees which pre-date grazing and fire exclusion; trees approximately 150 to 200 years or more in age. Retain most trees of species other than ponderosa pine for diversity, except on moist sites where encroachment by shade- tolerant trees creates ladder fuels.

2. **Reduce Stocking Levels** – Reduce tree densities to numbers more closely resembling pre-1870 conditions by thinning from below all post-settlement trees, except those needed to emulate or ultimately develop pre-settlement densities and diameter distributions. Trees-per-acre prior to European settlement are estimated at 25 to 50 or more. For mountain pine beetle control, approximately 145 trees per acre is the maximum level recommended, except as may be necessary for wildlife habitat.

3. Distribute Trees in Groups – Standing trees left after thinning operations should be grouped and clumped in a fashion that more closely resembles pre-1870 stand structures. Even spacing of trees is not desirable. Density should vary throughout forest stands from open pockets with no or few trees to dense pockets of trees with up to 150 trees per acre. Within forest stands or project areas strive for and, over time, develop irregular stand structure and spatial arrangement. Historical stand structure appears to have been comprised of even-aged groups of trees that varied widely in size and shape. Often two, three and sometimes more age and size groups were represented in a stand.

4. Keep Standing Dead Trees (Snag Retention) – In areas of general treatment, strive to save most standing snags, particularly those larger than 10 inches in diameter. Retention of snags within fuel breaks, defensible spaces, along trail and road corridors and within recreation areas must be evaluated on an individual basis.

5. Create Openings – Openings are considered to be areas with no to very few trees and a crown closure of 10 percent or less. Research has revealed that historic stands were extremely open, with more than 90 percent of the landscape having crown closures of 30 percent or less. Openings of up to 40 acres or more were found widely distributed across the landscape. Most openings were small, however, in the two to five-acre range, with only a few of the very large openings present.

Jennifer Chase

Restoration of ponderosa pine forests often results in the rejuvenation of native understory vegetation.

6. Conduct Prescribed Burning – Prescribed burning should be used, where appropriate, to reduce fuel loads, expose mineral soil, provide a nutrient flush to soils, reduce competition and stimulate production of grasses and forbs that may have evolved under periodic fire cycles. Maintenance burns will likely be needed within 3 to 10 years of the initial prescribed burn to reintroduce a periodic fire regime to sites where such a regime existed previously. To reduce catastrophic fire risk as well as return fire safely to its historical role in the ecosystem, sites often need to have existing fuel loads reduces prior to burning.

7. Monitor Natural Regeneration – Research has shown that openings in the presettlement forest were persistent and long lasting. It is important to decide early in the management of an area which openings are to be maintained over time, as that will dictate maintenance needs. Generally, regeneration of other areas will be by natural seeding. If regeneration is lacking, planting can be used to achieve the desired density. If too many young trees in an area survive prescribed fire, some can be removed to achieve specified density levels.

8. Manage Grazing Activity – Grazing activity should be managed and monitored during one to three years following the initial treatment to help establish and spread grasses and forbs in the understory.

9. Work to Control Noxious Weeds – Noxious weed problems should be addressed prior to thinning and prescribed burning to reduce their potential for spread. Learn and apply the proper cultivation and control tools, including grazing and proper timing of fire that can reduce the spread potential of weeds.

Community Actions

In communities throughout the state, people representing diverse interests have come together to explore on-the-ground solutions to ponderosa pine management. The most successful of these efforts involve multiple ownerships, use the best available scientific information, and monitor treatment results in order to improve future actions. Many of these coalitions are also exploring related management challenges such as fuel treatment costs, disposal of resulting woody materials, and the need for broad public engagement and support.

Community Wildfire Protection Plans, as described in the recently passed *Healthy Forests Restoration Act*, provide a new vehicle for bringing together diverse local interests to discuss their mutual concerns for public safety, community sustainability and natural resources. Participation in this planning process will allow communities to assess fuels treatment needs in a broader, solution-oriented context that also considers ecosystem restoration issues, fire response capability and individual responsibility for home-site protection.

• Ponderosa Pine Forest Partnership

The Ponderosa Pine Forest Partnership began in 1992 with a meeting in Dolores, Colorado to discuss concerns over forest conditions, wildfire risks, and the steady decline occurring in the local timber industry. From this meeting came a coalition of federal and state land managers, scientists, local government officials and timber industry representatives that was committed to finding a sustainable solution to both of these challenges.

Carla Harper

Community leaders, scientists, land managers and industry representatives joined to make the Ponderosa Pine Forest Partnership a success.

Partnership members designed an innovative restoration experiment that incorporated both ecological and economic objectives. The treatment prescription was based on a recent scientific assessment (by Dr. Bill Romme) that revealed current forest densities to be much higher than prior to Euro-American settlement. The treatment's four main goals were to: (1) reduce canopy density and restore small openings and clumps of trees similar to those found in pre-1880 stands; (2) reintroduce low-intensity fire; (3) stimulate greater productivity in understory vegetation; and (4) provide timber for local sawmills.

The Partnership, through a variety of contractors, conducted treatments from 1995 to 1998. All treatments involved ecological monitoring and research and many tested new harvesting and wood utilization techniques. In 2001, a scientific review team endorsed the Partnership's approach and encouraged them to expand their treatments on the landscape. Although the financial costs of treatment remain a challenge, the Partnership has experience no legal challenges and continues to work towards the goal of implementing and refining an ecologically and economically sound prescription for restoration of ponderosa pine in southwestern Colorado. They credit their success to early involvement from researchers and stakeholders and solid support from the local community.

• Greater Laramie Foothills Project

The Greater Laramie Foothills Project encompasses approximately 700,000 acres in north-central Colorado where altered fire regimes have been determined to pose a significant threat to ecological sustainability. The Project is one of three in Colorado to be incorporated into the Nature Conservancy's Fire Learning Network. Through this Network, the Nature Conservancy and their diverse partners hope to accelerate ecological restoration on high priority landscapes by fostering innovation and technology transfer in regional learning networks.

In addition to ponderosa pine woodlands, the Laramie Foothills landscape includes cliff and canyon systems, mixed grass prairie, shrublands, pinyon-juniper woodlands and juniper savanna. Restoration of ponderosa pine conditions is Project members' highest priority due to the potential impacts of large-scale or high-intensity wildfire on both communities and natural resources. Representatives from the Project's core team have participated in a number of workshops across the nation designed to help Learning Network affiliates approach landscape restoration through an ecologically sound and community-based approach.

Work to date is founded on an assessment of historic natural conditions and the use of computer-aided modeling to establish desired future conditions across the landscape. Participants are in the process of identifying high-priority ponderosa pine stands for treatment and have already designed a multi-scale monitoring plan for project implementation. Recent community meetings have increased local engagement in the Project's efforts.

• Harris Park Community Wildfire Protection Plan

The Harris Park Community Wildfire Protection Plan (CWPP) includes over 22 communities in the Platte Canyon and Elk Creek Fire Protection Districts approximately 50 miles southwest of Denver. These communities are surrounded by mid to high elevation ponderosa pine forests, many of which have experienced severe fires within the last ten years. In addition to private ownership, the Harris Park landscape also includes Staunton State Park and over 18,000 acres of U.S. Forest Service property.

Work on the community wildfire protection plan began with an assessment of fuel hazards, fire risk and values threatened in the Harris Park region. From this analysis, land managers established a prioritized list of areas in need of treatment to protect communities. The next step will be to develop individual fuels treatment plans for each high priority landscape. Prescribed treatments will include forest wide thinnings, restoration harvests, fuelbreak development and defensible space implementation around homes. Plan participants hope to coordinate ongoing management at Staunton State Park with future activities on private and U.S. Forest Service land. By implementing fuels treatment in a cross-boundary manner, they will be able to maximize community protection opportunities.

The final stage of the Harris Park Community Wildfire Protection Plan will involve numerous public meetings and workshops to explain the analysis and fuels treatment options defined in the document. The Fire Protection Districts will lead these community outreach efforts with assistance from the Colorado State Forest Service.

Dr. Tim Rohrer

Fuels mitigation activity in Staunton State Park will provide a foundation for future management in the Harris Park area.

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Colorado Department of Natural Resources
Division of Forestry

1313 Sherman Street, Room 718
Denver, Colorado 80203
(303) 866-3311
www.dnr.state.co.us

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